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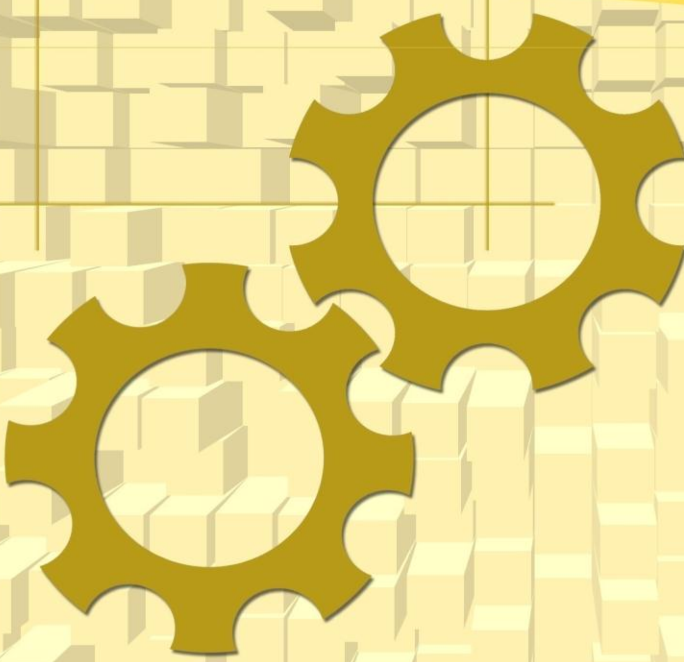

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SPOT WELD GROWTH ON MEDIUM CARBON STEEL (PART 1)

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ABSTRACT
Medium carbon steel is very common material that used in automotive industries for its mechanical assembly today. So the joining mechanism has to be low cost; reliable and last longer. In such situation the automotive industries are preferred to use the resistance spot welding. The robustness of mechanical assemblies is mainly anticipated and it relies on the proper weld joint. Hence this paper is analyzing the characteristic of medium carbon steel's weld joints with respected to its basic controlling parameters (current, weld time and force) changes. The entire experiment was carried out by varying the current and weld time at first attempt and the current and force at second attempt. Eventually the welded specimens were underwent tensile, hardness, and metallurgical test to relate the changes that happened due to the controlling parameters changes.

Keywords: Medium carbon steel, Carbon steel welding, Spot welding of steel.

1. INTRODUCTION

Resistance spot welding is a welding technique that joins two or more metal sheets through fusion at the contact area of electrode tips. This process basically uses two copper electrodes to compress the sheets together and supplies huge amount of current (typically kA) through the contact area of electrodes. The flow of current against the base metal resistance causes heat development between the sheets and gradually melts the concerned areas. Once the current flow is stopped the melted area will be hardened, then. The melted and solidified areas of base metals are thereafter called as weld nuggets and it consists of three zones. They are named as fusion zone (FZ), heat affected zone (HAZ) and base metals (BM). The proper joints between sheets are usually created at the fusion zone due to the thermal expansion of materials. The following, heat affected zones are appeared due to the thermal conductivity (54 W $m^{-1}$$\cdot$$K^{-1}$ (min)) of base metals and the other part of base metals remained unchanged. The weld nuggets' growths are therefore determined by the basic controlling parameters; primarily the welding current, welding time, electrode pressing force and electrode tips diameter. These are the four common parameters that enable a weld growth and also produce sound welds to prolong the stiffness of any metal joints. In this experiment the current, weld time and force were varied to characterize the weld growth while electrode tip remained unchanged.

2. EXPERIMENTATION

The base metals were rectangular in shape with equal size (200mm x 25mm x 1mm) as shown in Figure 1 and its chemical properties are tabulated in Table 1.

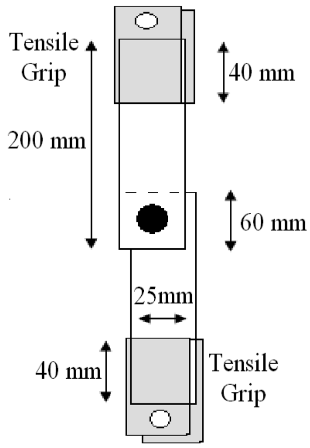

Figure 1 Test Sample

Table 1 Chemical Composition

Medium Carbon Steel						
Element	C	Cu	Mn	P	S	Si
Weight %	0.40	0.016	0.90	0.04	0.05	0.006

A pair of water cooled copper electrodes with tip (truncated) diameters of 5 mm was used to join these base metals. The test samples were initially placed on the top of lower electrode (tip) of the welder as overlaying 60mm on each other and then the initiating pedal was pressed. The weld process was started right after with squeezing cycles and; once the squeezing force is reached the welding current is delivered in accordance with the given preset values. Thereafter the electrode pressing mechanism (pneumatic based) consumes some time for cold work and eventually return to the home position of electrode. These process controlling parameters (current, weld time and force) are set before the welding process starts. Moreover we have conducted some test in advance to finalize the weld lobe for 1mm base metals and it has been presented in Figure 2.

Based on such combination of values; a weld schedule (Table 2) was developed to conduct the entire experiment to understand the basic parameter changes that cause the weld growth in 1mm-medium carbon steels.

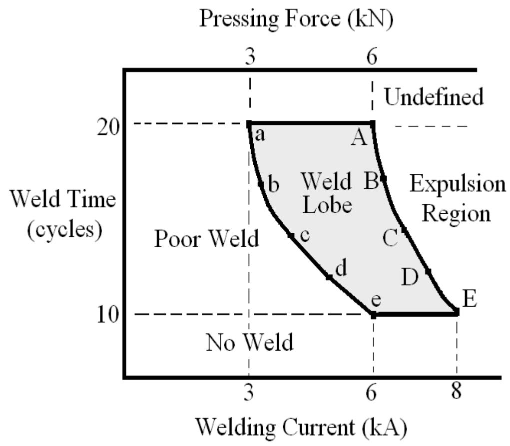

Figure 2 Weld Lobe for 1mm Sample Sheets.

Table 2 Weld Schedule

Both				a) Current and Weld Time		b) Current and Force	
Sample No	Weld Schedule	Electrode Tip (mm)	Current (kA)	Time (cycle)	Force (kN)	Time (cycle)	Force (kN)
1-5	1	5	6	10	3	10	3
6-10	2	5	7	10	3	10	3
11-15	3	5	8	10	3	10	3
16-20	4	5	6	15	3	10	4.5
21-25	5	5	7	15	3	10	4.5
26-30	6	5	8	15	3	10	4.5
31-35	7	5	6	20	3	10	6
36-40	8	5	7	20	3	10	6
41-45	9	5	8	20	3	10	6

The combinations of the eighteen (18) weld schedules were developed for both: a) the current and weld time variations as well as b) the current and force variations as shown in Table 2. Seven samples were welded in each of the weld schedule as tensile test uses five, hardness test uses one and metallurgical test uses the balance-one. The welded samples of base metals were undergone common strength tests that of the tensile shear tests in this experiment. Besides, the hardness test was carried out to understand the hardness changes due to the presence of high current (heat treatment) at the welded areas and also its' surrounding areas. The results of these two tests were insufficient to understand the nuggets characteristic and therefore the metallurgical study was carried out to complete the analysis in part 1.

3. RESULTS AND DISSCUSSION

3.1 Tensile Test Results

The tensile-shear test (Figure 3) was carried out using hundred kilo Newton (100 kN) capacity machine to determine the strength of spot welded samples of both (current and weld time; current and force) sets.

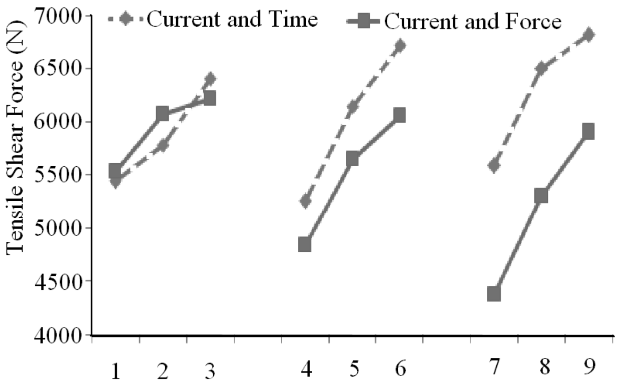

Figure 3 Tensile Shear Test Results

The crosshead speed was maintained at 70 mm/min. The ultimate tensile strength (UTS) was taken as the maximum weld strength after which the weld joints have broken. Average strength values from the five samples were taken as the equivalent strength of that particular weld schedules. As for the weld schedules from 1 to 2 and 2 to 3 were analyzed; the strength increment was noticed due to the increment of welding current from 6 to 7 and 7 to 8 kA respectively. The similar increments were also noticed for the following weld schedules of 4, 5 and 6 as well as 7, 8, and 9. This obviously states that increase in current has caused increase in strength due to the increase in diameters, according to Marashi et al. (2008). The Figure 4 shows the diameters changes with respect to current; weld time and force changes. These currents increment is found in both set of attempts. When the current and weld time incremental set is considered: the weld time too has increased the strength as it increases the diameters as well. This fulfils the Joule's law of heating ($Q = I^2Rt$); where Q represents the heat developed; I represents the current; R represent the resistance and t represent the time given. By increasing; either current or weld time; the heat supplied at the electrode tip is also equivalently increased and therefore the corresponding diameters increments were obtained. However when the current and force incremental set is considered: the force increase has caused drop in strength because of the drop of heat. As for the force from 3 to 4.5 and 4.5 to 6 kN; the tensile strength is reduced because the resistive components were reduced in the heating process which is another proportional coefficient of heat formula. Thus: the resistance is reduced by producing